Overview and Summary of Advanced UVOIR Mirror Technology Development (AMTD) Project

ABSTRACT

ASTRO2010 Decadal Survey stated that an advanced large-aperture ultraviolet, optical, near-infrared (UVOIR) telescope is required to enable the next generation of compelling astrophysics and exoplanet science; and, that present technology is not mature enough to affordably build and launch any potential UVOIR mission concept.

AMTD is a multiyear effort to develop, demonstrate and mature critical technologies to TRL-6 by 2018 so that a viable flight mission can be proposed to the 2020 Decadal Review.

AMTD builds on the state of art (SOA) defined by over 30 years of monolithic & segmented ground & space-telescope mirror technology to mature six key technologies:

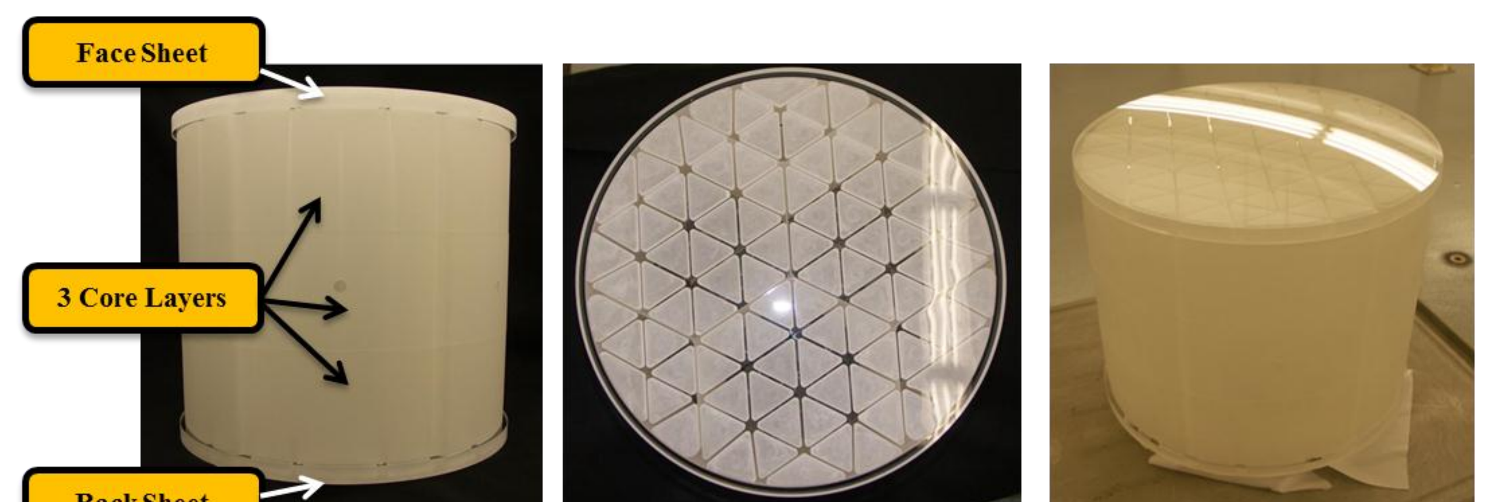
- *Large-Aperture, Low Areal Density, High Stiffness Mirror Substrates:* Both (4 to 8 m) monolithic and (8 to 16 m) segmented telescopes require larger and stiffer mirrors.
- *Support System:* Large-aperture mirrors require large support systems to ensure that they survive launch, deploy on orbit, and maintain a stable, undistorted shape.
- *Mid/High Spatial Frequency Figure Error:* Very smooth mirror is critical for producing high-quality point spread function (PSF) for high contrast imaging.
- *Segment Edges:* The quality of segment edges impacts PSF for high-contrast imaging applications, contributes to stray light noise, and affects total collecting aperture.
- *Segment to Segment Gap Phasing:* Segment phasing is critical for producing high-quality temporally-stable PSF.
- *Integrated Model Validation:* On-orbit performance is driven by mechanical & thermal stability. Compliance cannot be 100% tested, but relies on modeling.

Because we cannot predict the future, AMTD is pursuing multiple design paths to provide the science community with options to enable either large aperture monolithic or segmented mirrors with clear engineering metrics traceable to science requirements.

ACCOMPLISHMENTS & PLANS

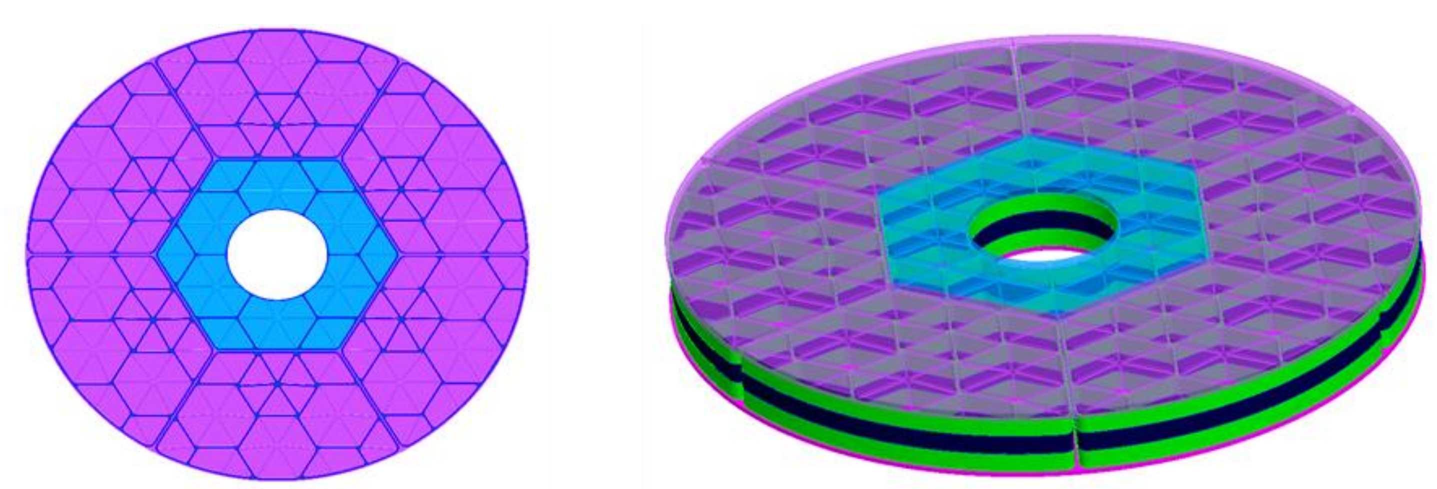
AMTD derived, from Science Requirements, Engineering Specifications for m monolithic and segmented space mirrors

Large-Aperture, Low Areal Density, High Stiffness Mirror Substrates: AMTD partner Exelis developed and demonstrated a technique to manufacture a 400 mm thick mirror substrate via 'stacking and fusing' core structural elements to front and back faceplates; making a 43 cm 'cut-out' of a 4 meter diameter 40 kg/m^2 mirror. New process offers a lower cost approach for manufacturing large-diameter high-stiffness substrates.

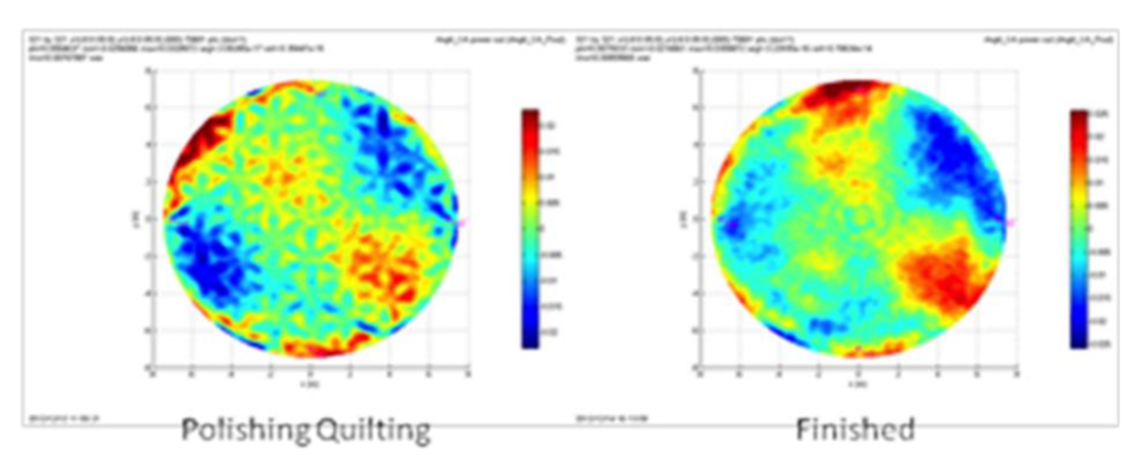


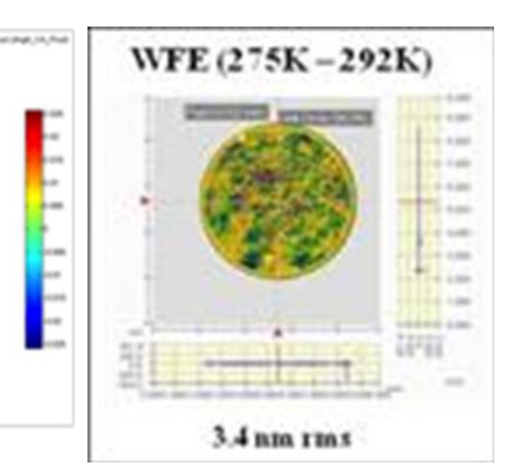
Post-Fusion Side View *3 Core Layers and Vent Hole Visible* | **Post-Fusion Top View** *Pocket Milled Faceplate* | **Post Slump:** *2.5 meter Radius of Curvature*

Phase 2 plans to make a 1.35 m x 135 mm (1/3rd of 4 m) mirror



Mid/High Spatial Frequency Figure Error: AMTD partner Exelis polished the 43 cm mirror to a zero-gravity figure of 5.5 nm rms. NASA MSFC tested less than 4 nm rms error at 275K.





Integrated Model Validation: AMTD modeled the 43 cm mirror and measured its static mechanical and dynamic thermal behavior.

Figure 8: 43-cm mirror test setup.

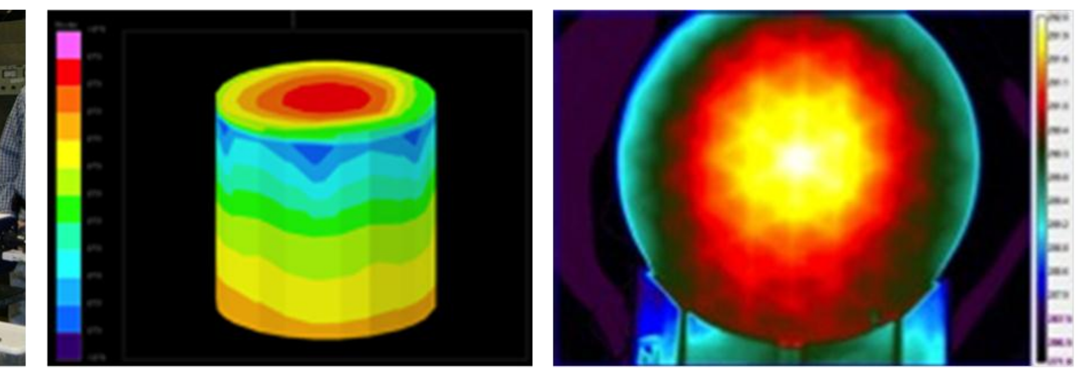
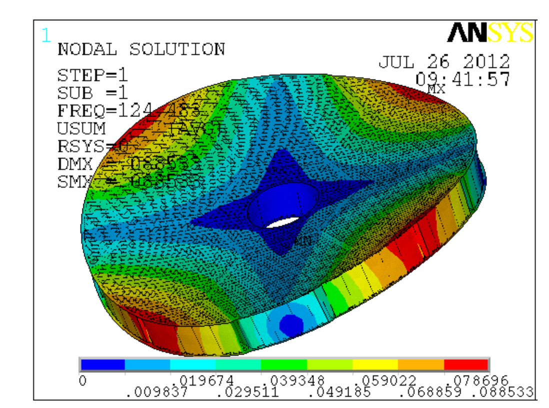


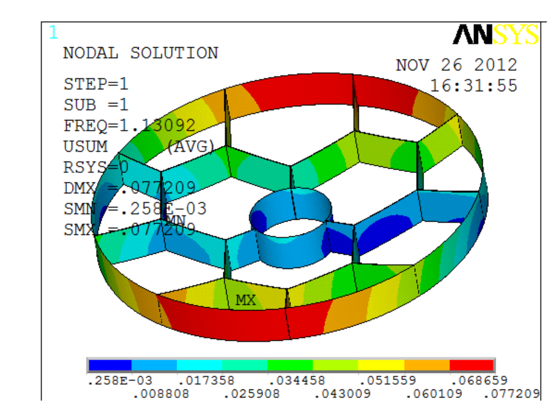
Figure 9: Predicted Thermal Model (left) vs. Measure Performance (right)

Modeling: AMTD has developed a powerful design tool which quickly creates monolithic and segmented mirror substrate designs with integrated support systems and analyze their static & dynamic mechanical and thermal performance.

Support System: Pre-Phase-A point designs for candidate primary mirror architectures have been produced.



Free-Free First Mode: 4 m dia 40 cm thick substrate



Internal Stress Distribution: 4 m mirror with 6 support pads

The AMTD TEAM

AMTD assembled an outstanding team from academia, industry & government; experts in science & space telescope engineering; to implement a science-driven systems engineering approach to define & execute a long-term strategy to mature technologies necessary to enable future large aperture space telescopes.

Science Advisory Team:
- Dr. Marc Postman, STScI
- Dr. Remi Soummer, STScI
- Dr. Annand Sivramakrishnan, STScI
- Dr. Bruce Macintosh, LLNL
- Dr. Olivier Guyon, UoA
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Systems Engineering Team
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- Laura Abplanatp, Exelis
- William Arnold, DAI/Jacobs
- Ron Eng, NASA